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PROGRAM

OF THE

CHICAGO MEETING

NOVEMBER 25-26, 1927

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CHICAGO MEETING NOVEMBER 25–26, 1927

The 147th regular meeting of the American Physical Society will be held in Chicago, Illinois, at the Ryerson Physical Laboratory on Friday and Saturday, November 25 and 26, 1927. The first session will be at 10 o'clock on Friday morning.

On Saturday morning two sessions will be held, in Rooms 32 and 33.

Titles and abstracts of the papers to be presented are given in the following pages. These abstracts have not been corrected by the authors. After correction, they will be published in an early number of the Physical Review. Authors should send corrections to the Editor of the Physical Review at 1500 University Avenue, S. W. Minneapolis, Minn.

Dinner. On Friday evening at 7 o'clock there will be a dinner for members of the Society and their friends at the Quadrangle Club. The price per person will be $1.50. Tickets must be purchased before 2 o'clock Friday afternoon.

CALENDAR

Friday morning at 10 o'clock.	Room 32: Papers 1–10.
Friday afternoon at 2 o'clock.	Room 32: Papers 11–21.
Friday evening at 7 o'clock.	Dinner at the Quadrangle Club.
Saturday morning at 10 o'clock.	Room 32: Papers 22–30.
	Room 33: Papers 31–40.
Saturday afternoon at 2 o'clock.	Room 32: Papers 41–48.

The supplementary papers beginning with No. 49 may be called for at the end of any one of the sessions held in Room 32.

Nashville Meeting. The 148th regular meeting of the American Physical Society will be held in Nashville. December 28–30, 1927, in affiliation with Section B—Physics—of The American Association for the Advancement of

Science. Members intending to present papers at this meeting should have titles and abstracts (**not exceeding 200 words**) *ready for publication*, in the hands of the Secretary *not later than Tuesday, November 29.*

Other meetings for the current season are as follows:

149. February 25, 1928. New York.

150. Pacific Coast Section—Place not yet determined.

151. April 10–21, 1928. Washington.

152. Pacific Coast Section—Place not yet determined.

HAROLD W. WEBB, *Secretary*
Columbia University, New York City.

PROGRAM

FRIDAY MORNING AT 10 O'CLOCK

Room 32

1. A proposed method for determining whether or not an electron has a magnetic moment comparable with that of a hydrogen atom. V. M. ALBERS AND T. E. PHIPPS, University of Illinois.—The magnetic moment of the hydrogen atom has been measured by Phipps and Taylor and found to be 6050 gauss cm per gram atom. This may be due to the electron in the atom having a magnetic moment. Phipps and Taylor have suggested a means of measuring this magnetic moment by passing a beam of electrons through a region in which an inhomogeneous magnetic and an inhomogeneous electric field are superimposed. Brillouin has suggested that if a beam of electrons is passed into an inhomogeneous magnetic field at an angle θ to the direction of the field, the electrons will so orient themselves that part of them will have the velocity component parallel to the field increased while the others will have this velocity component decreased. If the velocity is gradually decreased a value should be reached such that the electron current will change from i to $i/2$. The authors are planning to try a modification of the method proposed by Brillouin in which the electrons will be generated within the magnetic field and will then travel parallel to it. This removes the difficulty of leading a beam of electrons into a strong magnetic field.

2. Measurements of non-homogeneous magnetic fields. J. KUNZ AND J. T. TYKOCINER, University of Illinois.—The method proposed by these authors has been applied to the non-homogeneous magnetic field which is used in the determination of the magneton. The precautions necessary for accurate measurements are indicated and the results so far obtained are given.

3. Magnetic properties of evaporated films of nickel. K. J. MILLER, University of Iowa.—Films of nickel on a base of aluminum foil produced by evaporation from a white hot filament at pressures less than 4×10^{-4} mm of mercury were tested by a ballistic method in fields up to 167 gauss. Temperatures of the depositing base ranged from 100° to not less than 250°C. The coercive force reached a value approximately three times the value for hard drawn nickel wire from which the films were made. The values of the coercive force increased with the amount of heat applied to the film during deposit. These values agreed in magnitude with the results previously published and were found to decrease gradually with increasing thickness of the films. No thickness which was critical with respect to the coercive force was found up to 331 millimicrons. Values of the retentivity were observed as high as 60% and a variation with the temperature of deposit but none with the thickness was apparent. Results point to a structural difference between these films and bulk metal which is quite separate from any effect due to the base and probably dependent upon differences in crystal size.

4. Comparison of Corbino and Hall effects in silver and brass. K. K. SMITH AND H. M. O'BRYAN, Northwestern University.—The Corbino effect, measured by the torque on a circular disk carrying a radial current in a magnetic field gave (Phys. Rev. **8**, 402 (1916)) a coefficient E of the same order of magnitude as R/ρ, where R is the Hall coefficient, and ρ the resistivity. But for each metal tested E was considerably less than R/ρ. The method of measuring the Corbino effect has been improved in order to determine whether there is a real discrepancy. The torque acting upon the disk is balanced by sending a controlling current through one turn of insulated wire encircling the disk. The currents are led in and out through two pairs of spirals of silver ribbon. In fields of 8880 and 10100 gausses, E for silver is -5.9×10^{-7} and -5.8×10^{-7}, respectively. Using a rectangular plate of silver, we find, by the method devised by Heaps (Phys. Rev. **12**, 340 (1918)), $E=-5.0\times10^{-7}$, and $R=-8.6\times10^{-4}$, which agrees well with accepted values of the Hall coefficient. Taking this value of R, and the average value of E, we have $R/E=1.5\times10^{3}$, which is approximately equal to ρ for silver. Measures on a rectangular plate of brass indicate, likewise, that the theoretical relation is satisfied.

5. Resistance change of bismuth single crystals in a longitudinal magnetic field. G. W. SCHNEIDER, University of Iowa.—The change of resistance of single crystal wires of bismuth by a longitudinal magnetic field is found to be proportional to a power, slightly less than 2, of the field strength from 0 to about 3500 gauss. For a constant field strength (3480 gauss), the resistance change as a function of the crystal orientation (angle between vertical axis and

length of wire) shows maxima at orientations of 60° and 80°, and minima at 0°, 73°, and 90°. A single specimen whose orientation is subsequently changed by grinding shows a similar variation of resistance change with orientation. The specific resistance obeys the Voigt-Thomson symmetry relation.

6. Experimental test of Maxwell's distribution law. J. A. ELDRIDGE, University of Iowa.—A number of revolving coaxial discs with peripheral slots were used as a velocity filter. The distance between terminal discs was 12.7 cm and with a speed of 85 revolutions this gave a dispersion on the measuring plate of 1 mm for 2140 meters/sec. Cadmium vapor was used, the molecules being condensed upon a cooled glass surface after passing through the filter. The intensities of deposit were measured and were in rather satisfactory agreement with Maxwell's distribution law.

7. The problem of the normal hydrogen molecule. S. C. WANG, Columbia University.—The solution of Schroedinger's equation for the normal hydrogen molecule is approximated by the function $c\{e^{-s(r_1+\rho_2)/2a}+e^{-s(r_2+\rho_1)/2a}\}$, where $a=h^2/4\pi^2me^2$, r_1 and ρ_1 are the distances of one of the electrons to the two nuclei, and r_2 and ρ_2 those for the other electron. Then Z is so determined as to minimize the variational integral which generates Schroedinger's equation; besides, this minimum value just gives the approximate energy E. Strictly speaking, for every nuclear separation D there is a Z which gives the best approximation. In our calculation, however, we determine only that value for Z which corresponds to the D where the E-curve regarded as a function of D has a minimum and we use this same Z to compute the energy value at other separations. This minimum of E is found to be 2.278×the energy of a normal H-atom. It occurs at $D=1\cdot 41a$ which gives to the hydrogen molecule a moment of inertia $J=4.59\times10^{-41}$ gr. cm². From the curvature of the E-curve at this equilibrium point we obtain also the normal nuclear vibrational frequency $\nu_0=1.46\times10^{14}$ sec^{-1}. These results should be compared with the values $E=2.326R$ and $\nu_0=1.277\times10^{14}$ sec^{-1} obtained by Witmer from spectroscopic data.

8. The Zeeman effect for hydrogen in relativistic wave mechanics, and an application of the virial theorem. ARTHUR E. RUARK, Mellon Institute of Industrial Research, University of Pittsburgh, and Gulf Production Companies.—Using the relativistic wave equation, the Zeeman levels of hydrogenic atoms are determined, neglecting terms in H^2. The frequency of the Larmor precession is found to be $L=L_0(1+E/mc^2)$. Here L_0 is the frequency of precession obtained by Newtonian mechanics and E the energy of the atom. This agrees with a formula of Pauli obtained by ordinary relativity mechanics. (Zeit. f. Phys. **31,** 373, (1925)). The virial theorem shows that in a system of particles attracting or repelling each other with inverse square forces, twice the average kinetic energy is equal to the negative of the average potential energy. The generalization of this theorem which holds when a uniform constant magnetic field is present is deduced, and is applied to the theory of the Zeeman effect.

9. I. A unified theory of gravitation and electricity. CHESTER SNOW, Bureau of Standards.—All mass has electrical and (imaginary) magnetic field-producing aspects. Gravitation is described by two vectors e, h with field and force equations in which invariant mass is imaginary magnetism. Gravitation is propagated with the same velocity as electromagnetic light, its Poynting vector being $[h, e]$. Both kinds of light are deflected by gravitational and electrostatic fields. The metric tensor is not *identified* with gravitation but both fields are given symmetrical roles in determining it. Equations adopted for the metric field are $G^{\mu\nu}-\frac{1}{2}g^{\mu\nu}G=8\pi\nu c^{-2}(M^{\mu\nu}+E^{\mu\nu}-\nu e^{\mu\nu})$, gravitational field $(f^{\mu\nu})_\nu=-4\pi\rho_0 dx^\mu/ds$, electromagnetic $(F^{\mu\nu})_\nu=4\pi\sigma_0 dx^\mu/ds$, where $f_{\mu\nu}$ and $F_{\mu\nu}$ are each antisymmetric and curl of a potential. Particles depart from a four-dimensional geodetic line with equations of motion $c^2M(\ddot{x}^\mu+F_{\alpha\beta}{}^\mu\ddot{x}^\alpha\dot{x}^\beta)=-(QF_\alpha{}^\mu+\nu Mf_\alpha{}^\mu)\dot{x}^\alpha$. The theory gives the same advance of perihelion and bending of starlight by sun as Einstein's, but is mathematically distinct from his. Electric and magnetic (gravitational) charges are relative (like velocity) and physically indeterminate. They appear as projections of a charge-vector upon the time-like electrical axis and the space-like imaginary magnetic axis, which we may (and do) choose arbitrarily. Rotation of these axes in their plane would enable us to give an electron zero electric or zero magnetic charge, thus altering the form but not the content of our description of nature.

10. Corpuscular theory of light and gravitational shift. G. Y. RAINICH, University of Michigan. (Introduced by W. F. Colby.)—Usually the prediction of spectral shift in the light coming from regions of higher gravitational potential is based on the consideration of emitting

atoms as oscillating mechanisms, and the shift is connected with retardation of clocks. In this paper the question is considered in a more formal way from the point of view of the corpuscular theory of light in the form which it takes in the relativity theory. In the special theory a light ray, or photon, is considered as given by a vector of zero length freely movable along the line of its direction. It follows that all rays of light are absolutely equal, the difference in color is due to the difference in position with respect to the reference system (Doppler effect). In the general theory motion along a curve leads to a geodesic; colors of different rays can not be compared unless some universal time is introduced, but this question is not further discussed except in the special case of a centrosymmetric field where a preferred time exists. In this case the discussion is completed and leads to the usual result.

FRIDAY AFTERNOON AT 2 O'CLOCK

Room 32

11. The spectrum of the solar corona. IRA M. FREEMAN, University of Chicago (Introduced by H. B. Lemon).—Two thirds of the "unknown" lines of the coronal spectrum, (as given by the complete list of Campbell and Moore, Lick Observ. Bull., **10,** (1918)), have been identified with argon. About half of these have been fixed by direct comparison with known lines in the terrestrial spectrum of argon, and half are given by combinations of Meissner's term values for this element. Almost all of the strong coronal lines are among those identified. Because of the presence of Ca II in extremely high levels in the solar atmosphere, it was thought that the unknown lines might be attributed to this substance or to Ca III, as suggested by Pannekoek. No very close agreements in wave-length are found by comparison with the Ca spectra, but accurate pairing is possible with the lines of the argon atom, which, of course, has a structure much like Ca III. Another phase of the investigation disclosed seventeen groups of constant wave-number separations among the coronal lines; an arrangement of almost all the lines on a linkage diagram, similar to those employed by Hicks in his study of the complex spark spectra, is given. The linkage scheme has several interesting features; the equality of three of the lengths with term differences in argon first suggested the indentification.

12. The spectrum of beryllium. W. H. SANDERS AND V. M. ALBERS, University of Illinois.—The spectrum of beryllium has been photographed in the ultraviolet and visible regions using the vacuum spark as a source. A large number of lines have been measured. The arc in air and the spark in air have also been used as sources in the visible and infra-red regions. No lines or wave-lengths longer than 5271A have been obtained from the vacuum spark but some appear between 5000 and 8500A when the spark in air is used as a source. The band spectrum of BeO shows up very strongly when the arc in air is used as a source and it also appears when the spark in air is used, although much weaker than in the arc. The band spectrum is being studied for the purpose of determining the series relationships of the lines that make up the bands.

13. The vacuum spark spectrum of aluminum. R. F. PATON AND G. M. RASSWEILER, University of Illinois.—During an investigation of the spectrum of beryllium by Paton and Sanders in 1925, several photographs were taken of the vacuum spark spectrum of a beryllium-aluminum alloy. As known lines of aluminum appeared with considerable intensity, it seemed possible that some previously unobserved lines of this element might be present. Accordingly, a study of the vacuum spark spectrum of a sample of very pure aluminum was undertaken, using a quartz spectrograph. Particular attention was paid to the maintenance of very high vacua in the spark chamber in order that the voltage across the terminals might be high and the energy large. Long exposures yielded a surprisingly large number of new lines which are attributed to aluminum. Over forty have been listed in the region λ2200A to λ5000A, all of these forty appearing on several plates. Unexpected differences occur in the intensities of known aluminum lines on different plates apparently taken under similar conditions. Indeed, many of the heaviest lines listed by Paschen may be missing on one plate while appearing on other plates having in many respects the same intensity.

14. The spectra of tin and their Zeeman effects. J. B. GREEN, Ohio State University and R. A. Loring, Northwestern University.—(1) *Zeeman Effects* of the lines of the tin spectrum have enabled the authors to classify the spectra of tin in the neutral state and in two stages of ionization. (2) *The spectrum of neutral tin* has 5 low levels, $^3P_{012}$, $^1D_2{}^1$, $^1S_1{}'$, due to the configura-

tion $5_2 6_1$. The configuration $5_2 6_1$ yields $^3P_{012}'$ and $^1P_1'$. The configuration $5_2 5_2$ yields twelve terms of which the lowest four are definitely established. Pauli's *g-sum rule* is found to be valid. The ionization potential of Sn I is calculated as $7.37 \pm .05$ volts and the resonance potential 4.30 volts. (3) *The spectrum of Sn II* is a doublet spectrum like In I and the principal doublet separation found from some results of Lang is found to be 4353 cm^{-1}. Several series are noted, including lines due to abnormal states, the electrons having the configuration $5_1 5_2 5_2$. *The ionization potential* is computed as approximately 14.5 volts and the resonance potential 6.5 volts. (4) *The spectrum of Sn III* consists of singlets and triplets, like that of Cd I. Several series are noted, and the *ionization potential* calculated as about 30 volts, and the resonance potential as 6.81 volts. A very strong group in the extreme ultra-violet is classified as a pp' group. (5) Application of the *regular doublet law* leads to possible classifications in the spectrum of In II and Ge II.

15. Zeeman effect and spectral terms in the arc spectrum of platinum. A. C. HAUSSMANN, Hobart College.—The Zeeman effect of 173 platinum arc lines has been investigated in the region 5500 to 2500A, a field of 33,000 gauss and high dispersion spectrographs being used. It was found possible to identify 33 of these lines from their patterns. The g-values are found to be usually abnormal and the patterns sometimes unsymmetrical. From the Zeeman patterns, intensities in combinations and Meggers' absorption spectra, 12 low levels have been identified. These have been designated as follows: $^3D_3$, a^1D_2, $^3F_4$, $^1S_0$, $^3D_2$, $^3F_3$, $^3D_1$, $^3P_2$, $^3F_2$, $^3P_1$, $^1G_4$, b^1D_2. $^3D_3$, d^9s is the groundterm. The assignment agrees well with the predictions of the Hund theory and Meggers and Laporte. There are 72 levels altogether divided into 12 low, 45 intermediate and 15 high levels. An attempt was made to identify the intermediate levels from intensities in combinations but no multiplicity has been assigned. To combinations between these 72 levels, there are attributed 376 lines. These account for practically all the strong lines in the arc spectrum.

16. Unclassified lines of the indium arc spectrum. JOHN G. FRAYNE, Antioch College.—While studying stages in the excitation of the arc spectrum of indium Frayne and Jarvis re-reported the occurrence of the following five unclassified lines at 6.9 volts: viz. 3051.19, 2957.01, 2858.30, 2836.91, and 2775.35. The wave number difference of the first and third of these is 2211.71, while the difference of the second and fifth is 2212.51. This number equals $2p_2 - 2p_1$ for indium. Hence we may write 3051.19 as $2p_1 - x_1$ and 2858.30 as $2p_2 - x_1$. It has not been found possible to fit the second pair into any series scheme with the first pair. They may be written as follows: 2957.01 as $2p_1 - x_2$ and 2775.35 as $2p_2 - x_2$. The values of x_1 and x_2 are 11680 and 10645 resp. The four lines classified above appeared prominently on all plates. Hence the energy levels denoted by x_1 and x_2 cannot be neglected in any picture of the indium atom. The line 2858.30 remains unclassified.

17. Hyperfine structure of the mercury triplet $2^3P_{0,1,2} - 2^3S_1$ when excited optically. E. HOBART COLLINS, University of Iowa.—Lummer-Gehrcke plates have been used to study the hyperfine structures of λλ5461, 4358 and 4047 of the optically excited mercury spectrum. The hyperfine structures of these lines are found to depend upon the manner in which the upper level is reached. For example, only one of the hyperfine structure components of λ5461 appears when that line is excited by absorption of λ4358, while two additional components appear when the excitation is by both 4358 and 4047. The interpretation of the results in terms of hyperfine structure energy levels is discussed.

18. Extension of the first positive group of nitrogen bands. A. H. POETKER, Marquette University.—An investigation of the infra-red portion of the first positive group of nitrogen bands by thermocouple and prism has extended that group to the region of 1.5μ. The broad radiation maxima corresponding to the higher sequences have been broken up into individual bands. Their observed maxima occur at the positions calculated from the known vibration levels of this group. For higher accuracy the region from 7500 to 10500A was photographed under a dispersion of 9A per mm with neocyanin plates. The bands were recorded as far as 10500, the beginning of the 0 sequence. The new data obtained by this extension of the spectrum point very definitely to a modification of the assignment of vibration numbers as previously made by Birge. In this reassignment the origin of the entire group, or the $0-0$ transition, is at 1.04μ. All the band and sequence designations change accordingly. The evidence pointing to this as the more probable assignment is discussed.

19. Extension of the violet CN band system to include the CN tail bands. F. A. JENKINS, New York University.—The CN spectrum produced by acetylene in active nitrogen has been photographed with a dispersion of 0.95A per mm and resolving power 220,000. Fine-structure analysis of the so-called tail bands confirms a suggestion of Mulliken that they constitute the higher members of the ordinary CN sequences in which the frequencies of the bands have passed through a maximum and decreased sufficiently for the bands to appear on the long-wave side of the more intense first members. The opposite direction of shading in the tail bands is to be expected according to the general rule that $B'-B''$ has the same sign as $\Omega'-\Omega''$. Except for large variations in the degree of rotational doubling, and several remarkable perturbations in the line series, the structure of the tail bands is identical with that of the ordinary CN bands. Extrapolation of the constant $B(=h/\pi^2 I)$ permits the assignment of vibrational quantum numbers in the three sequences of tail bands measured. Thus the first band on the low-frequency side of the (0, 0) band is the (10, 10) band. An accurate representation of the molecular constants in the states of higher vibrational quantum number is now possible. New bands belonging to the sequences $\Delta n=-2$ and $+3$ are recorded.

20. Voltage-intensity relations in the mercury spectrum. WILLIAM D. CROZIER, University of Iowa.—Voltage-intensity curves were obtained for twenty mercury lines excited by electron impact, using accelerating voltages from excitation to fifty volts. It is found that no significant change takes place in the number of atoms in a given energy state as the ionization potential is passed. The components of each of the dD groups of energy levels are excited at practically the same voltage but have quite different excitation functions. The excitation functions for d_1, d_2, and s levels and for the $2p_2$ level are similar in form and have sharp maxima within a few volts of excitation. The excitation functions for d_2 and D levels are similar, increasing uniformly to 30 or 40 volts where they have broad maxima. The voltage-intensity curves of lines originating in transitions down from the same initial level agree in type but sometimes show certain differences in shape. It appears that the probability of different transitions down from a given energy state may not be independent of the way in which this state was excited. There is evidence that a large number of excitations of $2p_2$ by transitions down from higher levels are not followed by $1S-2p_2$ transitions.

21. Effect of combined electric and magnetic fields on the helium spectrum. J. STUART FOSTER, McGill University.—Parallel electric and magnetic fields are obtained by placing a slightly modified Lo Surdo tube through the poles of a large electromagnet. The experimental conditions are such that the observed effect is mainly a normal (Lo Surdo) Stark effect upon which is superimposed a relatively small Zeeman splitting due to a uniform magnetic field of moderate strength. While many lines show the combined effect, the Stark component of $2P-5F$ which is characterized by $m=\pm 2$ in initial state has been selected as most suitable for quantitative measurements (See central component Plate 7(I), Proc. Roy. Soc., **114,** 47, (1927)). This component is split by the magnetic field into two components of equal intensity, and with a separation of 0.41A.

SATURDAY MORNING AT 10 O'CLOCK

Room 32

22. The magnetic deflection of a luminous canal ray beam in hydrogen. CHARLES J. BRASEFIELD, National Research Fellow, University of Chicago.—A study has been made of the effect of a transverse magnetic field on a luminous canal ray beam in hydrogen. Under favorable pressure conditions it is possible to deflect two separate beams from the main canal ray beam; one of these is due to the H_2^+ ion while the other is due to H^+. A measurement of the angle of deflection of the H^+ beam shows that the H^+ ion came thru the electric field as H_2^+, which then split into H^+ and H^0 before it reached the magnetic field. By varying the pressure of gas, the ratio of the intensity of the two beams can be varied over a great range. Observations made on the variation of this ratio with pressure lead to a value for the mean free path of the H_2^+ ion, for dissociation into H^+, of 0.2 cm at a pressure of 0.01 mm, which is one seventh of the kinetic theory value for the mean free path of a neutral hydrogen molecule. Another result of this calculation indicates that the path of the H^+ ion for excitation of light is fifty times that of the H_2^+ ion.

23. Electric arc stream dimensions determined by a new photographic method. W. B. NOTTINGHAM, Bartol Research Foundation, Franklin Institute.—Arc stream dimensions of cadmium and tungsten arcs have been determined by means of a carefully controlled photographic method. The results so far obtained indicate (1) that the average current density over any plane passed through the arc stream perpendicular to its axis is independent of the current. (2) The current density distribution in the neighborhood of the electrodes of the tungsten arc is independent of the arc length. (3) The current density at the cathode of the tungsten arc corresponds quite closely to the electron current density from tungsten at a temperature very slightly above the melting point. The fusion of the surface of the cathode indicates that the actual temperature is at least as high as the melting point. The electron emission data were taken from an extrapolation of the observations of Dushman, Rowe, Ewald and Kidner (Phys. Rev. **25,** 338, (1925)). (4) The current density at the cathode of the cadmium arc in argon has been found to be about 700 times the density one might reasonably expect to find as a result of the thermionic emission even at the temperature of boiling cadmium and assuming a work function of 1.5 volts.

24. The intensities of molecular beams. THOS. H. JOHNSON, Fellow of the Bartol Research Foundation, Franklin Institute.—A new method for studying molecular beams has been developed in which the beam is detected and its intensity is measured by the increase in pressure which takes place in an ionization gauge when the gauge is moved to allow the beam to enter it through a narrow slit. The method has been applied to the measurement of the intensities of beams of mercury molecules. The beam was formed by the diffusion of mercury molecules from a boiler through two slits between which stray molecules were condensed by a liquid air cooled surface. The intensity (I) of the beam (defined as the number of molecules which cross a normal plane per cm² per sec.) was found to depend upon the boiler pressure according to the relation $I = Ape^{-Bp}$ where A has the value which is calculated on the kinetic theory at very low pressures, i.e., on the assumption of molecular flow through the source slit and no scattering after passing the source slit, and B is a constant depending upon the efficiency of condensation between the slits. This leads to the result that more intense beams can be produced than were formerly thought possible.

25. Low pressure electric discharge. C. DEL ROSARIO, Fellow of the Bartol Research Foundation, Franklin Institute.—Previous work using a fine filament and a concentric cylinder (Journal of the Franklin Institute, February, 1927) was extended to higher voltages but smaller fields than those used before by the employment of thicker filaments. Moreover, a new design of experimental tube made it possible among other things to more completely outgas the filament. Four sizes of tungsten filaments ranging from 0.0013 to 0.0046 cm diameter were used. Keeping as nearly identical as possible the pressure (of the order of 10^{-8} mm Hg.) of residual gases and the degree of outgassing of the filament and other metal parts, it has been shown that the voltage rather than the field determines the current, curves for different filaments being practically superposable when plotted with voltages, although widely separated when plotted with fields. In all cases the log current-voltage curve was nearly straight and was displaced parallel to the voltage axis towards higher voltages with a slight decrease in slope for more complete filament outgassing. The temperature of the filament affected this curve very slightly until appreciable thermionic current set in. The slope decreased with increase of thermionic current and at the same time the curve was displaced towards lower voltages.

26. Ionization of water vapor. H. A. BARTON, Bartol Research Foundation and J. H. BARTLETT, Harvard University.—An electro-magnetic method of separating gas ions of different mass, such as that used by Dempster, has been employed in a study of the ions produced by electron impact in water vapor. The principal ions appearing were $(H_2O)^+$ and $(OH)^+$. Of these the $(H_2O)^+$ ions were more abundant. Unmistakable evidence was obtained that a third type of ion, probably $(H_3O)^+$, was produced in very small quantities. H^+ and H_2^+ ions were always very few in number or unobservable. No $(OH)^-$ or any other negative ions were observed. The ionization potential corresponding to $(H_2O)^+$ was 13 ± 1.5 volts, being probably in agreement with the ordinarily measured ionization potential. The $(OH)^+$ ionization potential was not distinguishably different, but it was difficult to measure this quantity owing to some overlapping of the $(H_2O)^+$ and $(OH)^+$ peaks. A study is being made of the variation in the relative abundance of the ions as a function of pressure.

27. Diffraction of electrons by a single layer of atoms. C. DAVISSON AND L. H. GERMER, Bell Telephone Laboratories, Inc.—A homogeneous beam of electrons is scattered by a crystal of nickel as if it were a beam of monochromatic radiation of wave-length h/mv. (Nature, **119,** 558, (1927). The phenomenon differs from x-ray scattering in that (1) the individual atom scatters the equivalent electron radiation more efficiently than it does x-radiation, and (2) the former radiation is extinguished in the metal much more rapidly than the latter; the intensity of a beam of electron radiation may be reduced 30 or 40% on passing normally through a single layer of atoms. A consequence is that an appreciably greater amount of scattered electron radiation issues from the first atom layer than from the second; more from the second than from the third, etc. These differences are accentuated for radiation leaving the crystal near grazing emergence, because in this region the path through the metal over which radiation from a subsurface layer escapes is greatly lengthened. The result is that near grazing first layer scattering is strongly predominant, and diffraction occurs as if waves were being scattered by a single layer of atoms only. Files of atoms serve as line gratings and ordinary line grating diffraction is observed.

28. Reflection of positive rays by a platinum surface. GEORGE E. READ, University of Buffalo. (Introduced by A. J. Dempster.)—In order to determine the variation of intensity with angle of positive rays scattered or reflected by metallic surfaces an arrangement similar to that of a spectrometer was set up in a good vacuum. It was found that slow lithium rays were regularly reflected from a "clean" platinum surface. Consistent results were obtained only when the platinum reflector had been heated white hot not more than a few seconds before each reading. Readings with a hot surface gave the same results as with a "clean" cold surface. The intensity of the reflected beam varied from zero with 10 volts accelerating potential up to a maximum around 40 volts and back to zero at 250 volts. Almost all the incident rays were reflected at the maximum. There was no indication of any reflected or scattered rays in the range from 250 to 800 volts. Most of the rays that were reflected had lost more than 0.6 of their original energy. In general the same results hold for potassium rays.

29. On the behavior of small quantities of radon at low temperatures and low pressures. ALOIS F. KOVIARK, Yale University.—A small quantity of radon, 1 to 20 millicuries, was first condensed at temperature of liquid air in a vessel of about 0.5 cm^3 volume and this vessel and others used in the experiments were exhausted to about 5×10^{-6} mm Hg. The bath surrounding the radon was brought to the temperature required and kept constant. During this existing condition the vessel was connected with another of much larger volume and kept so until equilibrium was apparently established. The two vessels were then disconnected and the gaseous radon in the second vessel was collected by means of cocoanut charcoal at liquid air temperature and measured. Pressure of the gaseous radon in the vessel at the studied temperature was determined by calculation. Results show a definite equilibrium between the gaseous radon and the radon condensed and indicate that the condensation is partly monatomic on the cooled surface of the vessel and partly frozen droplets of radon. This argument is supported by various observations and deductions. Vapor pressure-temperature relation was obtained. Volatilization temperatures were also determined.

30. Critical potentials of metals. H. B. WAHLIN, University of Wisconsin.—Critical potentials of metals in the solid state have been investigated by a number of observers, but investigations in the vapor state are meager and uncertain. The following method has been used successfully: A narrow beam of electrons is accelerated by a variable potential to a gauze made of the metal under investigation, and then accelerated to a small receiving plate by a potential which is kept constant. The gauze is heated and serves as a source of vapor. Electrons that are scattered by the vapor will not reach the receiver, but those that make inelastic collisions will be pulled over by the constant field. The critical potentials will then be indicated by an increase in the slope of the current-voltage curve. The following values have been found:

I. Cu, 1.61, 2.6, 3.8, 4.84, 5.65, 6.08, 6.73, 7.7, 8.26, 8.73, 9.4, 10.07, 10.91. With the exception of the 2.6, these have all been identified as optical levels.

II. Ag, 2.18, 2.89, 3.61, 4.28, 5.25, 5.96, 6.69, 7.54. The values 2.18, 2.89, 4.28, are non-optical.

III. Ni, 3.53, 5.02, 6.08, 6.85, 7.5, 8.0, 8.68, 9.45, 11.6, 12.8, 14.66, 16.1, 16.6. Those below 8 volts are probably all optical. The work is being extended.

SATURDAY MORNING AT 10 O'CLOCK

Room 33

31. Variations of atmospheric pressure as a possible contributing cause of static, of earth currents and their variations, and of variations on the earth's magnetic field. RICHARD HAMER, Pittsburgh, Pa.—A vertical glass tube filled with moist earth formed part of a closed circuit including a sensitive galvanometer. Sudden changes of air pressure caused variations to occur in the current which flowed due to electrolytic action in the soil acids at the electrodes. To eliminate effects due to pressure changes causing variations of soil resistance, the electrodes were insulated by glass dishes, one end earthed and the tube shielded. The insulated top electrode was connected to a quadrant electrometer. Similar pressure changes caused the electrometer to indicate the presence of a temporary charge at the electrodes. Apparently a temporary disturbance takes place in the distribution of the electrons or ions in the earth when sudden changes of air pressure occur. It is suggested that earth current measurements may be influenced by these two effects. The experiments also seem to afford obvious explanations of the many various known facts peculiar to propagation of radio waves especially in the case of reception. Possibly barometric changes cause variations in earth currents directly, and also indirectly by varying surface soil resistance. If these are large enough to produce observable magnetic effects, they may explain why magnetic variations seem to parallel those of earth currents.

32. The temperature coefficient of oscillating quartz plates. ROGER S. STROUT, University of Chicago. (Introduced by A. J. Dempster.)—The change of frequency with temperature of a quartz crystal plate $1.8\times1.8\times0.11$ cms, vibrating in a direction normal to its faces with a frequency of 2700 kc, was determined at various temperatures. A second oscillating plate was used as a fixed frequency, while the heterodyne note was heard with a receiving set. This second plate was maintained at, or near room temperature, and was reground to an appropriate frequency for each determination. The change of frequency with temperature was found to decrease linearly from 61.3 cycles per degree at 65°C to 4.3 cycles per degree at -189°C.

33. Dielectric constants of benzene, carbon disulphide, and carbon tetrachloride, and of dilute solutions of alcohols in these solvents. J. D. STRANATHAN, University of Chicago.—Using a high frequency beat method, the dielectric constants of benzene, carbon disulphide, and carbon tetrachloride have been determined at temperatures ranging from freezing to boiling. Dielectric constants of dilute solutions of methyl alcohol in benzene, methyl alcohol in carbon tetrachloride, and amyl alcohol in benzene have been determined at temperatures ranging from freezing to boiling. With hope of obtaining the electric moment of the alcohol in an unassociated state, curves of molecular polarization versus concentration (one curve for each ten degree temperature interval) were projected to the zero concentration axis. For methyl alcohol in benzene, these intercepts are consistent with the Debye theory, and lead to an electric moment 1.66×10^{-18} e.s.u. for methy alcohol. The intercepts for methyl alcohol in carbon tetrachloride are inconsistent with the Debye theory, possibly due to persistent association; assuming that association is absent at temperatures near boiling, the moment of the alcohol molecule is calculated to be 1.65×10^{-18}. Amyl alcohol in benzene leads to intercepts in accord with the Debye theory, and to an electric moment of 1.74×10^{-18}. Further work is in progress.

34. On the size-distribution of particles in reversible colloids. N. RASHEVSKY, Westinghouse Research Laboratory, East Pittsburgh and MRS. E. N. RASHEVSKY, Edgewood, Pa.—A sufficiently dilute polydisperse colloidal solution is considered as a mixture of an infinite number of monodysperse systems, and Planck's theory of dilute solutions is then applied to such a mixture. This gives the thermodynamic characteristic function of the colloid, which involves the distribution function for the size of particles. The requirement of the extremum of the characteristic function leads then to an expression for the distribution function. The distribution function thus obtained is in so far not quite determined, as it contains another function, which depends on the energy of the interaction of a colloidal particle with the solvent. Some general properties of this latter function are discussed, and it is shown, under what conditions the distribution function has a maximum for a finite radius of particles.

35. Dielectric constants of electrolytic solutions for various concentrations. A. P. CARMAN and C. C. SCHMIDT, University of Illinois.—The electrometer method (Carman, Phys. Rev. **24**, 396 (1924)) has been developed to measure dielectric constants of electrolytic solutions of considerable concentration. For NaCl solutions, the d.c. has been measured for equivalent

concentrations up to 0.02; for solutions of KCl, $BaCl_2$ and $CuSO_4$, concentrations up to 0.01, 0.022 and 0.026 respectively. These results are given in curves showing concentrations and corresponding dielectric constants. The d.c.-concentration curve for NaCl solutions, shows a decrease of d.c. up to a concentration of about 0.012, and then an abrupt increase of the d.c., and for concentrations above about 0.016, the d.c. is greater than that for water. The d.c.-concentration curve for KCl solutions is similar to that of NaCl solutions. The d.c.-concentrations for solutions of $BaCl_2$ and of $CuSO_4$ are peculiar in showing two minima, the d.c. of the more concentrated solutions in each case reaching values higher than that for water. The general explanation seems to be that suggested by Walden (Zeit. f. Phys. Chem. **116**, 228) who predicted part of the above results. Walden's explanation is, however, very general and did not predict curves with double minima.

36. Efficiencies in luminescence accompanying electrolysis. R. T. DUFFORD, University of Missouri.—The luminescence which occurs at the electrodes of an electrolytic cell under certain conditions, has been studied. The effect is found for a large number of solutions, and for several metals as electrodes, the most interesting cases being (a) aluminum electrodes in sodium phosphate or carbonate solutions, and (b) almost any metal in anhydrous ether solutions of Grignard reagents. Brightnesses measured range from 6×10^{-9} to above 10^{-5} lamberts; the brightness generally increases with the applied voltage. The energy radiated as visible light ranges from 10^{-5} to over 10^{-6} percent of the electrical input energy. The efficiency at first increases, then decreases, as the voltage is increased. It is not much affected by changes in concentration, and is similar in value for chemically similar solutions. Certain impurities in small amounts increase the efficiency over ten-fold.

37. Absorption of ultrasonic waves by some gases. T. P. ABELLO, University of Chicago.—Previous measurements of the absorption by CO_2 and hydrogen by the writer using a torsion vane to measure the intensity has shown a nearly logarithmic decrease of the intensity with the increase in the percentage of the gas. A new method of measuring the intensity has been used, namely, allowing the beam to fall upon another quartz crystal which has a natural frequency very nearly equal to that of the source of the waves, and which is connected to the grid of a thermionic tube. The received signal is then heterodyned, amplified and measured by a vacuum tube voltmeter. The reading of the latter is expressed in terms of the intensity of the beam striking the receiving crystal by placing in the path of the beam celluloid films of known transmitting power. The previous dependence on concentration was confirmed. The intensity is reduced to only 10 percent of the intensity observed with pure air, in going 3 cms in a mixture of 80 percent air with 20 percent carbon dioxide. The corresponding reduction is 34 percent with hydrogen and 47 with helium.

38. The velocity of sound in liquids. LOUIS G. POOLER, Columbia University, New York City.—An experimental method has been developed by which the velocity of sound in liquids can be determined with a high degree of percision. A column of liquid contained in a cylindrical vertical steel tube is brought into resonance vibration at audio frequency by an electromagnetically excited diaphragm at the bottom. When the resonance frequency of the vibrating liquid is the same as that of the diaphragm the reaction of the latter on the system is very small. Gronwall (Phys. Rev. **30**, 71, (1927)) has shown that due to the elasticity of the walls of the tube the true velocity of sound C_0, in the liquid is given by the expression $C_0=C/(1-\epsilon)$, where $C=2L\nu$, ν being the resonance frequency of the diaphragm alone, L the height of the column of liquid and ϵ a function of the inner and outer radii of the tube, the elastic constants of the material of the tube and the density of the liquid. The theory was verified experimentally using tubes and diaphragms of different thicknesses. The velocity of sound in air-free distilled water at 25°C was found to be 1493.2 ± 2.3 m/s. The rate of change of velocity with temperature is 2.2 m/s per degree in the interval 25–30°C and decreases to 0.4 m/s per degree from 60–70°C. The compressibility κ of the liquid has been calculated from the expression $\kappa=\rho C_0^2$ where ρ is the density of the liquid.

39. Compressibilities of liquids by the sonic interferometer. J. C. HUBBARD, Johns Hopkins University and A. L. LOOMIS, The Alfred Loomis Laboratory, Tuxedo Park, N. Y.—Preliminary results on the velocity of sound in liquids obtained by a resonance method at frequencies of 200 to 500 kilocycles have been published by the authors (Nature, Aug. 6, 1927). The precision of these measurements has been increased and several new methods of detection of the nodal points have been developed. For routine work the main oscillator is heterodyned with a quartz oscillator, the heterodyne note being kept in tune with an electrically driven fork by varying the tuning of a small vernier condenser. The vernier condenser readings pass

through cyclic changes with very sharp maxima as the piston of the interferometer is displaced. Acoustic wave-lengths in the liquid are measured to one part in ten thousand, but the absolute values of velocity of sound are one order less precise, being limited by the precision of calibration of the wave meter. A study over a wide range of temperatures of the velocity of sound in water, in mercury, and in a number of salt solutions has been made. The adiabatic compressibilities of these substances have been calculated as well as the ratio of specific heats for the substances for which c_p is known.

40. The absorption of sound by materials. F. R. WATSON, University of Illinois.—An experimental investigation was made by Sabine's reverberation method of a number of materials. Several modifications were introduced. The source of sound was a telephone receiver, actuated by an audible frequency audion oscillator that allowed a flexible variation of frequency with a wide range of intensity. Purity of tone was sought by adjusting the oscillator and by attaching a Helmholtz resonator over the telephone receiver. The intensity of the sound produced was measured with a Rayleigh disc. The interference sound pattern in the room was shifted continuously by installing the telephone source of sound at the top of an oscillating pendulum, mounted by ball bearings at the center. Measurement of open window absorption gave agreement with the theoretical value (unity) within a few percent. Results were obtained for a number of materials for pitches 256, 512, 1024 and 2048. (A complete account of the investigation will appear soon as Bulletin No. 172 of the University of Illinois Engineering Experiment Station.)

SATURDAY AFTERNOON AT 2 O'CLOCK

Room 32

41. The effect of x-rays upon the Faraday time lags, the Faraday effect and the optical rotation in several liquids. FRED ALLISON, Alabama Polytechnic Institute.—Differences in the time lags of the Faraday effect behind the magnetic field in various liquids have been measured by Beams and Allison (Phys. Rev. **29,** 161 and **30,** 66 (1927)). Certain considerations led the writer to suspect that these time lags might be affected by the action of x-rays upon the liquids. It is found from a number of experimental tests that x-rays do have such a property. In every case the time lag differences vanished so long as the liquids were exposed to the x-rays, and reappeared with screening off the x-rays. The method affords a means of measuring the absolute time lag of the Faraday effect. It was then decided to ascertain whether these rays could influence the rotation of the plane of polarization of light in these liquids. A series of tests shows that a beam of x-rays traversing the liquids induces in them the power of rotating the plane of polarization, though it is small. Observations were also made to detect an influence of x-rays upon the Faraday effect, with the result that the x-rays slightly increase the rotation. The liquids used are carbon bisulphide, carbon tetrachloride, toluene, benzene, xylene, chloroform and water.

42. The scattering of x-rays from H_2, O_2, and CO_2. CHARLES S. BARRETT, University of Chicago.—Radiation from a water cooled molybdenum tube (55,000 peak volts, 60 ma.) was passed through balanced filters (suggested by Ross) of strontium and zirconium, giving a monochromatic beam containing 40% of the original Kα intensity, none of the Kβ line, and less than 5% of any other wave-length. This beam was scattered from gases contained in a cylinder having thin celluloid windows, in which the gas pressure was varied from 0.5 to 335 cm. A large ionization chamber received the scattered rays at different angles ($\theta = 19°$ to 90°) from the primary beam. The curve of intensity vs. θ has approximately the same shape for CO_2 and O_2 but a different shape for H_2. On the same scale at $\theta = 90°$, the H_2 curve falls below the average of the CO_2 and O_2 curves as θ decreases; at 40° being about 75% of the average of the others, and at 19° about 30%. Using monochromatic radiation (.71A) the H_2 curve does not differ from the H_2 curve using heterogeneous radiation (reduced to the same scale) by more than a probable error of 5%. The irregularities in the curve which are predicted by the classical theory calculations of Debye, Compton, and others, due to interference of rays from pairs of electrons assumed at constant distances apart, are not observed on the H_2 curve though the slit system was capable of resolving them.

43. An attempt to find a unidirectional effect of x-ray photons. A. H. COMPTON, K. N. MATHUR and H. R. SARNA, Punjab University, Lahore, India.—The directive emission of photo-electrons by polarized x-rays suggests that each photon may act in a preferred direction on an electron, and that this direction remains fixed as the photon moves through space. It seemed possible that x-ray pulses excited by the impact of cathode particles on a target

might emit more photons with their electric axes antiparallel to the cathode stream than parallel to it, corresponding to Stoke's unidirectional pulse. We might then expect more photo-electrons to be ejected parallel to the cathode rays than antiparallel. This was tested by passing a narrow sheet of x-rays from the tungsten target of a Coolidge x-ray tube midway between two wire gauzes separating an ionization chamber into two portions. One portion received the photo-electrons ejected parallel and the other those antiparallel to the cathode ray beam. At the December 1926 meeting of the Indian Science Congress, preliminary results were reported which indicated a slight excess of photo-electrons in the parallel direction. Later, more refined experiments, however, failed to show any inequality between the parallel and the antiparallel emission as great as 1 part in 500. Potentials from 50 to 110 kv were employed, with and without filters for the x-rays.

44. The structure and dimensions of the benzene ring. JARED KIRTLAND MORSE, University of Chicago.—In a previous paper (Proc. Nat. Acad. Sci. **13**, 227 (1927)) it was shown that the crystal lattices of diamond and graphite could be built up of cubes having one corner in common. The radii of these cubes were 0.77A and 0.75A respectively. In this paper a *scale* model of the benzene ring is presented, built up of cubes, of radius 0.76A having single corners in common. The carbon atoms form an octahedral arrangement while the atoms of the substituted groups attached to the Carbon atoms of the ring are on the corners of a plane hexagon. Isomerism, unsaturation and non-occurrence of optically active derivatives are all accounted for by this model. In addition to its theoretical interest, this model, offers a definite quantitative basis on which to interpret the x-ray data obtained from organic crystals of the aromatic compounds.

45. The diffraction of x-rays in liquid normal monobasic fatty acids. ROGER M. MORROW State University of Iowa.—Eleven of the normal monobasic fatty acids in the liquid state have been investigated with MoKα radiation. The results are similar to those previously reported for the liquid primary alcohols by Stewart and Morrow. There are two spacings found by the application of Braggs' law, one of which is the lateral separation of the molecules which lie in parallel collinear chains, and the other the separation of the planes passing transversely through the chains and containing the diffraction centers of the molecules. The lateral spacing is 4.55A for the samples having more than five carbon atoms to the molecule. This is in agreement with the values found by Stewart and Morrow for the primary *n*-alcohols and with the work of Adam on monomolecular films. The longitudinal spacing varies linearly with the carbon content, the increase being 2.00A for two molecules. In the molecular arrangement, the chains are not normal to the transverse planes and there are two molecules in series, with associated COOH groups, for each spacing. A comparison of data for the acids in the liquid and crystalline states shows that the arrangement of molecules in the cybotactic state is not that found in the crystalline state.

46. X-ray diffraction in liquids: isomers of primary alcohols. G. W. STEWART, University of Iowa, and E. W. SKINNER, Olivet College.—This is a continuation of the work of Stewart and Morrow on the primary normal alcohols. Nine isomers were investigated, one of *n*-butyl, five of *n*-amyl, one of *x*-hexyl, and two of *n*-heptyl alcohol. The attachment of CH_3 as a side branch alters the "diameter" by 0.6A, and of OH, by 0.4A. The attachment of CH_3 and OH to the same atom in the chain increases the diameter by only 0.65A. The measured "diameter" of the molecule is a mean value, but in the case of di-n-propyl carbinol there is a better resolution and the side attachment of OH increases the diameter in one direction by 0.45A and in the other not at all. The existence is shown of associated polar groups giving two molecules in a continuous chain for each longitudinal spacing. When the OH group is not attached to the last or next to the last atom in the chain, this association disappears and there is but one molecule for each longitudinal spacing. This is in agreement with the experiments of others on similar chains in the solid state. In one case, triethyl carbinol, the first, third and fifth orders of the side spacing are apparently present.

47. Crystal structure of certain of the alums. J. M. CORK, University of Michigan.—The many isomorphous members of the alum group differing from one another by the replacement of a single atom provide an interesting series for x-ray examination. Rotation photographs were employed to determine the space group. Intensity measurements by a Bragg ionization spectrometer for all available orders for each of the principal plane sets, allowed the determination of the lattice constants and possible arrangements for the various atoms in the complete structure. The electron distribution along a line perpendicular to the principal plane sets and

hence atomic positions is determined by the method of Fourier analysis and confirmed by structure factor calculations. The following lattice constants were observed: $NH_4 \cdot Al(SO_4)_2 \cdot 12 H_2O$, 12.18A; $K \cdot Al(SO_4)_2\ 12H_2O$, 12 · 14A; $KCr(SO_4)_2 \cdot 12H_2O$, 12.14A; $RbAl(SO_4)_2 \cdot 12H_2O$, 12.20A; $CsAl(SO_4)_2\ 12H_2O$, 12.31A and $Tl\ Al(SO_4)_2 \cdot 12H_2O$, 12.21A.

48. Preferred orientation in tungsten crystals caused by mechanical working. H. B. DeVore and Wheeler P. Davey, The Pennsylvania State College.—A sheet of rolled tungsten, 2 mils thick was heated nearly to its melting point, thus causing those crystals which had a preferred orientation to grow at the expense of the fragments of the other crystals. Diffraction patterns of the foil taken with a pin hole slit were interpreted by mounting a model of a tungsten crystal in front of a copy of the diffraction pattern. A string represented the incident beam. The string and a normal to a given atomic plane determined the plane of the beam diffracted by that plane, and if the model were correctly oriented the spot in the experimental diffraction pattern had to lie in that plane as though it were the reflection of a beam of light passing along the string. The direction of rolling of the foil was in the general direction of the face-diagonal of the crystal and the cube face made an average angle of 13° to the direction of rolling, with a deviation of ±3° from the mean orientation. It is believed that this angle between the cube face and the surface of the foil depends upon the diameter of the rolls and upon the percent reduction per pass. Results with drawn tungsten wires were consistent with the above.

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member, one only of these will be assigned a place on the regular program, while the others will be placed in a supplementary program, to be called for if time permits.

Papers received after the program has been printed will be placed in the supplementary program.

The papers in the supplementary program may be called for at any session in Room 32 after the completion of the regular program for the session.

49. II. Gravitation and electricity as manifestations of a six-dimensional world. Chester Snow, Bureau of Standards.—This theory indicates space-time is part of a six-dimensional, cylindrical world, R_6, whose line element may be put into the form $(d\lambda)^2 = \gamma_{\mu\nu}\, dx^\mu\, dx^\nu$ (μ, ν summed 1 to 6) $= g_{mn}\, dx^m\, dx^n + (\phi_m dx^m + dx^5)^2 - (\psi_m\, dx^m + dx^6)^2$ (m, n summed 1 to 4), where $\gamma_{\mu\nu}$ do not involve x^5 and x^6 and where ϕ_m and ψ_m are proportional to the electromagnetic and gravitational 4-potentials respectively. In any space the tensor $G^{\mu\nu} - \frac{1}{2}\gamma^{\mu\nu} G$ must have important geometrical significance. If all those components vanish in which space-time suffixes enter, the three equations of electromagnetic, gravitational, and metric fields, which I have adopted, are satisfied and conversely. The real electrical direction, x^5, is time-like. The indeterminateness of charge corresponds to a sort of Lorentz transformation. The unity of gravitation and electricity lies in the fact that charge is a complex vector whose magnitude is intrinsic but whose mode of resolution into space-like and time-like components is non-essential. The equations of motion of a charged particle, which I have also adopted, in both electromagnetic and gravitational fields mean that it is following a geodetic line in the six-dimensional world.

50. A simple derivation of the energies of circular hydrogenic orbits in wave mechanics. Arthur E. Ruark, Mellon Institute of Industrial Research, University of Pittsburgh, and Gulf Production Companies.—Let p, r, E be angular momentum, radius, and energy of a circular hydrogenic orbit, respectively. The virial theorem shows that $p^2 = -2mr^2E$ and $-Ze^2/2r = E$. Eliminating r, $p^2 = -Z^2\, me^4/2E$. We form the wave equation by replacing p by $h/2\pi\ \partial/\partial\phi$, and applying to ψ the operator thus obtained, ψ being the wave function. The wave equation is $d^2\psi/d\phi^2 + K^2\psi = 0$, with $K^2 = -2\pi^2\, me^4 Z^2/h^2 E$. Therefore $\psi = e^{ik\phi}$ and to make this have the same period as the electronic motion, we must have $E_k = -2\pi^2\, me^4\, Z^2/h^2k^2$, where k is integral. The formula for ψ is incomplete, but the energy values are correct. The corresponding relativistic formula and the azimuthal selection principle are also easily obtained.

51. Note on the theory of the longitudinal Hall effect. J. A. Eldridge, University of Iowa.—Attention is called to a consideration of simple electrodynamical nature which is usually overlooked in the theory. If one considers the warping of the electric field due to the Hall effect and the consequent increase of the field and considers as well the increase of current obtained by vector addition of the Hall current to that due to this field, the kinetic theory gives a decrease in resistance in disagreement with experiment.